Background

Hepatocellular carcinoma (HCC) is the most common primary hepatic malignancy, typically arises in cirrhotic livers, is the second most common cause of death related to cancer¹. Currently, the only definitive cure for HCC is liver transplantation. However, available organs are limited and thus several staging systems have been developed in attempt to appropriately allocate donor livers. Early and accurate radiologic diagnosis is critical not only to the staging systems (and thus organ allocation) but to the survival of the patient². In recent years, several interventional therapies have been developed to treat HCC, with the goal of bridging the patient to transplant. Among these are radiofrequency or microwave ablation, transarterial chemoembolization (TACE), and transarterial administration of Yttrium-90 (Y-90) radiotherapy beads. TACE is the most studied of these methods and several papers have demonstrated its benefit in both overall survival and bridging patients to transplant³⁴. Evaluating response to treatment and excluding progression of disease is paramount in this population to determine which patients remain eligible for transplantation. Currently, the standard of care for HCC detection and followup consists of multiphase contrast-enhanced CT or MRI. The process of detecting, measuring, and diagnosing HCC is time-consuming, especially considering the lesions are often multiple and need to be compared to prior exams to evaluate for interval change. Thus, software that could expedite this portion of the radiologic evaluation without sacrificing sensitivity or accuracy would be of immense value to the radiologist, and a potential avenue for artificial intelligence (AI).

Purpose

To test the ability of semi-automated volumetric segmentation software to detect and measure viable hepatocellular carcinoma (HCC) on dual-energy CT (DECT) before and after transarterial chemoembolization (TACE), compared to explant pathology data.

Materials and Methods

Inclusion: HCC patients with standardized multiphasic hepatic DECT pre- and post-TACE, followed by transplantation within 90 days of follow-up DECT. Software measurements included liver volume, and for HCC ≥ 1 cm diameter: tumor cross-sectional area, volume, Hounsfield units, and iodine content. Measurements were performed on 70 keV, 52 keV, and iodine density DECT image data acquired in late hepatic arterial phase for each lesion by single operator. Ability to detect measurable enhancement and iodine content in HCC lesions after treatment was cross-referenced to explant pathology reports to evaluate viability concordance. Semi-automated seeding accuracy was assessed for each DECT image type; measurement accuracy was graded on a scale of 0-5: grade 0- software unable to autocontour despite visible enhancement; grade 1- no correction; grade 2- minor under-measurement; grade 3- minor over-measurement; grade 4- major over-measurement; “mixed”- contained both over- and under-measurement requiring significant correction. Minor corrections required less than 30 seconds to correct while major corrections required greater than 30 seconds of manual correction.

Results

Prospective Single-center database of 662 patients transplanted from 2011-2016: 27 patients (mean age 59.4; 16 M) with 40 lesions met inclusion criteria. Mean±std dev measured liver volume was 1557±462 mg; observed pathologic volume was 1459±160 mg (p=0.39); lesion size pre-TACE was 2.49±1.16 cm, on explant 2.45±1.42 (p=0.90); post-TACE (viable component) 1.28±0.29 cm, and did not vary with image type (p=0.62, ANOVA). Of 40 lesions, 22 (55%) were found to be 100% necrotic at explant and demonstrated a lack of measurable enhancement on post-TACE images; 18 (45%) lesions demonstrated viability at explant ranging from 1% to 100%; 3 lesions demonstrated no measurable enhancement despite presence of tumor at explant; 2 pathology proven viable tumors developed in the patient population on pre-transplant DECT but were not present on pre-TACE imaging. There were only two instances of inability to autocontour a lesion on any DECT image type. A total of 277 measurements were performed, with distribution of Grades 0-5 (in order): 17, 16, 42, 125, 38, and 26; 13 measurements were “mixed” error. Subtle enhancement was subjectively best on 52 keV DECT images. The 70 keV DECT images required least correction after autocontour, with 57% of lesion measurements requiring no correction, compared to 56% at 52 keV and 52% on iodine MD. Iodine MD images were the most difficult to autocontour, as 20% of visibly enhancing lesions failed to register automatically.

Limitations

• Retrospective population
• Limitation of correlation with pathology reports (prospective in future)
• Selection bias potentially related to DECT rather than MRI or standard CT population
• Software tested was vendor specific
• Did not attempt to blind workstation operator to pathology
• Did not use multireader approach (future plans)

Conclusion

DECT image data on 70 keV, 52 keV and iodine images allow accurate and reproducible volumetric liver and promising but variable lesion analyses using semiautomated software. However, fully automated calculation of post TACE residual tumor burden requires further refinement as 49% of measurements required correction of some kind.

References